

### Claims

1. A monolithic, tandem photovoltaic (PV) cell comprising:  
a compliant silicon substrate including a base silicon layer having a first PV subcell formed therein,  
a conductive perovskite layer, and a  $\text{SiO}_2$  layer interposed between the conductive perovskite layer  
and the base silicon layer;  
a second PV subcell positioned above the compliant silicon substrate; and  
electrical contacts operably connected to the PV cell to conduct current to and from the PV  
cell.
2. A monolithic, tandem PV cell as defined in claim 1, wherein the conductive perovskite layer  
comprises electron doped strontium titanate.
3. A monolithic, tandem PV cell as defined in claim 1, wherein the conductive perovskite layer  
comprises strontium ruthenate.
4. A monolithic, tandem PV cell as defined in claim 1, wherein the conductive perovskite layer  
comprises  $\text{Sr}_{1-x}\text{La}_x\text{TiO}_3$ .
5. A monolithic, tandem PV cell as defined in claim 1, wherein the conductive perovskite layer  
comprises  $\text{SrTi}_{1-x}\text{Nb}_x\text{O}_3$ .
6. A monolithic, tandem PV cell as defined in claim 1, wherein the conductive perovskite layer  
comprises  $\text{SrTiO}_{3-\delta}$ , where  $0 < \delta < 0.3$ .
7. A monolithic, tandem PV cell as defined in claim 1, wherein the second PV subcell is formed  
of a group III-V direct band-gap semiconductor material.
8. A monolithic, tandem PV cell as defined in claim 7, wherein the group III-V direct band-gap  
semiconductor material comprises  $\text{GaAs}_x\text{P}_{1-x}$ .
9. A monolithic, tandem PV cell as defined in claim 7, wherein the group III-V direct band-gap  
semiconductor material comprises  $\text{Ga}_x\text{In}_{1-x}\text{P}$ .
10. A monolithic, tandem PV cell as defined in claim 7, wherein the group III-V direct band-gap  
semiconductor material comprises GaAs.
11. A monolithic, tandem PV cell as defined in claim 1, wherein the conductive perovskite layer  
comprises electron doped strontium titanate and the second PV subcell is formed of a group III-V  
direct band-gap semiconductor material.

12. A monolithic, tandem PV cell as defined in claim 1, wherein the conductive perovskite layer comprises strontium ruthenate and the second PV subcell is formed of a group III-V direct band-gap semiconductor material.
13. A monolithic, tandem PV cell as defined in claim 1, further comprising an electrically conductive interconnection layer interposed between the compliant silicon substrate and the second subcell.
14. A monolithic, tandem PV cell as defined in claim 13, further comprising a back surface reflector (BSR) layer interposed between the interconnection layer and the second subcell.
15. A monolithic, tandem PV cell as defined in claim 14, wherein the BSR layer is formed of a material selected from a group consisting of  $\text{Ga}_x\text{In}_{1-x}\text{P}$ ,  $\text{Al}_x\text{In}_{1-x}\text{P}$ , and  $\text{Al}_x\text{Ga}_{1-x}\text{In}_{1-y}\text{P}$ .
16. A monolithic, tandem PV cell as defined in claim 15, wherein the BSR layer has a thickness of between  $0.01\mu\text{m}$  and  $0.1\mu\text{m}$ .
17. A monolithic, tandem PV cell as defined in claim 1, wherein the conductive perovskite layer has a thickness of  $30\text{ \AA}$  to  $300\text{ \AA}$ .
18. A monolithic, tandem PV cell as defined in claim 17, wherein the  $\text{SiO}_2$  layer has a thickness of between  $5\text{ \AA}$  and  $12\text{ \AA}$ .
19. A monolithic, tandem PV cell as defined in claim 18, wherein the base silicon layer has a thickness of between  $50$  to  $150\text{ }\mu\text{m}$ .
20. A multi-junction, monolithic, photovoltaic (PV) cell configured for producing a photocurrent when exposed to photons, comprising:
- a compliant substrate including a base layer having a first PV subcell formed therein, a conductive perovskite layer, and an oxide layer interposed between the conductive perovskite layer and the base layer;
  - a second PV subcell monolithically formed above the compliant silicon substrate;
  - an electrically conductive interconnection layer interposed between the compliant substrate and the second PV subcell; and
  - electrical contacts operably connected to the PV cell to conduct current to and from the PV cell.
21. A multi-junction, monolithic, PV cell as defined in claim 20, wherein the base layer is formed of monocrystalline silicon.

22. A multi-junction, monolithic, PV cell as defined in claim 21, wherein the oxide layer is formed of  $\text{SiO}_2$ .
23. A multi-junction, monolithic, PV cell as defined in claim 20, wherein the conductive perovskite layer comprises electron doped strontium titanate.
24. A multi-junction, monolithic, PV cell as defined in claim 20, wherein the conductive perovskite layer comprises  $\text{Sr}_{1-x}\text{La}_x\text{TiO}_3$ .
25. A multi-junction, monolithic, PV cell as defined in claim 20, wherein the conductive perovskite layer comprises  $\text{SrTi}_{1-x}\text{Nb}_x\text{O}_3$ .
26. A multi-junction, monolithic, PV cell as defined in claim 20, wherein the conductive perovskite layer comprises  $\text{SrTiO}_{3-\delta}$ .
27. A multi-junction, monolithic, PV cell as defined in claim 20, wherein the second PV subcell is fabricated from a group III-V direct band-gap semiconductor material.
28. A multi-junction, monolithic, PV cell as defined in claim 27, wherein the group III-V direct band-gap semiconductor material comprises  $\text{GaAs}_x\text{P}_{1-x}$ .
29. A multi-junction, monolithic, PV cell as defined in claim 27, wherein the group III-V direct band-gap semiconductor material comprises  $\text{Ga}_x\text{In}_{1-x}\text{P}$ .
30. A multi-junction, monolithic, PV cell as defined in claim 27, wherein the group III-V direct band-gap semiconductor material comprises GaAs.
31. A multi-PV subcell, monolithic, photovoltaic (PV) cell configured for producing a photocurrent when exposed to photons, comprising:
- a compliant silicon substrate including a base silicon layer having a first PV subcell formed therein, a conductive perovskite layer, and an oxide layer interposed between the conductive perovskite layer and the base silicon layer;
- a second PV subcell formed of a group III-V direct band-gap semiconductor material; and
- a third PV subcell formed of a group III-V direct band-gap semiconductor material.
32. A multi-PV subcell, monolithic, PV cell as defined in claim 31, wherein the third PV subcell is formed of  $\text{Ga}_x\text{In}_{1-x}\text{P}$ .
33. A multi-PV subcell, monolithic, PV cell as defined in claim 32, wherein the second PV subcell is formed of  $\text{GaAs}_x\text{P}_{1-x}$ .
34. A multi-PV subcell, monolithic, PV cell as defined in claim 32, wherein the second PV subcell is formed of GaAs.

35. A multi-PV subcell, monolithic, PV cell as defined in claim 31, further comprising a first electrically conductive interconnection layer interposed between the compliant silicon substrate and the second PV subcell and a second electrically conductive interconnection layer interposed between the second PV subcell and the third PV cell.

36. A multi-PV subcell, monolithic, PV cell as defined in claim 35, further comprising a first back surface reflector layer interposed between the first electrically conductive interconnection layer and the second PV subcell.

37. A multi-PV subcell, monolithic, PV cell as defined in claim 36, further comprising a second back surface reflector layer interposed between the second electrically conductive interconnection layer and the third PV subcell.

38. A multi-PV subcell, monolithic, PV cell as defined in claim 36, wherein the first electrically conductive interconnection layer and the second electrically conductive interconnection layer comprise tunnel junctions.

39. A multi-PV subcell, monolithic, PV cell as defined in claim 31, wherein the conductive perovskite layer comprises electron doped strontium titanate.

40. A multi-PV subcell, monolithic, PV cell as defined in claim 39, wherein the conductive perovskite layer comprises  $\text{Sr}_{1-x}\text{La}_x\text{TiO}_3$ .

41. A multi-PV subcell, monolithic, PV cell as defined in claim 39, wherein the conductive perovskite layer comprises  $\text{SrTi}_{1-x}\text{Nb}_x\text{O}_3$ .

42. A multi-PV subcell, monolithic, PV cell as defined in claim 31, wherein the conductive perovskite layer comprises  $\text{SrTiO}_{3-\delta}$ .

43. A multi-PV subcell, monolithic, PV cell as defined in claim 31, wherein the conductive perovskite layer comprises strontium ruthenate.

44. A method of forming a multi-junction, monolithic, photovoltaic (PV) cell, comprising:  
forming n-type and p-type regions in a base silicon layer to create a first PV subcell within the base silicon layer;

forming a conductive perovskite layer above the base silicon layer;

forming an oxide layer between the conductive perovskite layer and the base silicon layer; and

forming a second PV subcell of a group III-V direct band-gap semiconductor material above the conductive perovskite layer.

45. A method of forming a multi-junction, monolithic, PV cell as defined in claim 44, further comprising forming a third PV subcell of a group III-V direct band-gap semiconductor material above the second PV subcell.
46. A method of forming a multi-junction, monolithic, PV cell as defined in claim 44, further comprising forming a first electrically conductive interconnection layer between the conductive perovskite layer and the second PV subcell.
47. A method of forming a multi-junction, monolithic, PV cell as defined in claim 46, further comprising forming a first back surface reflector layer between the first electrically conductive interconnection layer and the second PV subcell.
48. A method of forming a multi-junction, monolithic, PV cell as defined in claim 45, further comprising forming a first electrically conductive interconnection layer between the conductive perovskite layer and the second PV subcell and a second electrically conductive interconnection layer between the second PV subcell and the third PV subcell.
49. A method of forming a multi-junction, monolithic, PV cell as defined in claim 48, further comprising forming a first back surface reflector (BSR) layer between the first electrically conductive interconnection layer and the second PV subcell, forming a second BSR layer between the second PV subcell and the second electrically conductive interconnection layer, and forming a third BSR layer between the second electrically conductive interconnection layer and the third PV subcell.
50. A method of forming a multi-junction, monolithic, PV cell as defined in claim 49, further comprising forming a window layer above the third PV subcell.
51. A method of forming a multi-junction, monolithic, PV cell as defined in claim 44, wherein the conductive perovskite layer is formed of  $\text{Sr}_{1-x}\text{La}_x\text{TiO}_3$ .
52. A method of forming a multi-junction, monolithic, PV cell as defined in claim 44, wherein the conductive perovskite layer is formed of  $\text{SrTi}_{1-x}\text{Nb}_x\text{O}_3$ .
53. A method of forming a multi-junction, monolithic, PV cell as defined in claim 44, wherein the conductive perovskite layer is formed of  $\text{SrTiO}_{3-\delta}$ .
54. A method of forming a multi-junction, monolithic, PV cell as defined in claim 44, wherein the conductive perovskite layer is formed of strontium ruthenate.
55. A method of forming a multi-junction, monolithic, PV cell as defined in claim 44, wherein the second PV subcell is formed of  $\text{GaAs}_x\text{P}_{1-x}$ .

56. A method of forming a multi-junction, monolithic, PV cell as defined in claim 44, wherein the second PV subcell is formed of  $\text{Ga}_x\text{In}_{1-x}\text{P}$ .

57. A method of forming a multi-junction, monolithic, PV cell as defined in claim 44, wherein the second PV subcell is formed of GaAs.

58. A method of forming a multi-junction, monolithic, PV cell as defined in claim 45, wherein the third PV subcell is formed of  $\text{Ga}_x\text{In}_{1-x}\text{P}$ .

59. A method of forming a multi-junction, monolithic, PV cell as defined in claim 58, wherein the second PV subcell is formed of GaAs.

60. A method of forming a multi-junction, monolithic, PV cell as defined in claim 58, wherein the second PV subcell is formed of  $\text{GaAs}_x\text{P}_{1-x}$ .

61. A monolithic, tandem photovoltaic (PV) cell comprising:  
a compliant silicon substrate including a base silicon layer having a first PV subcell formed therein, a perovskite layer, and a  $\text{SiO}_2$  layer having a thickness of between 5 Å and 12 Å interposed between the conductive perovskite layer and the base silicon layer;

a second PV subcell positioned above the compliant silicon substrate; and  
electrical contacts operably connected to the PV cell to conduct current to and from the PV cell.

62. A multi-PV subcell, monolithic, PV cell as defined in claim 61, wherein the perovskite layer is between 30 Å and 300 Å.

63. A multi-PV subcell, monolithic, PV cell as defined in claim 62, wherein the perovskite layer comprises strontium titanate.